



Original Contribution

# Does ED crowding decrease the number of procedures a physician in training performs? A prospective observational study<sup>☆</sup>

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## Abstract

**Purpose:** The aim of the study was to determine whether the number of procedures performed by residents and medical students in the emergency department (ED) is affected by ED crowding.

**Methods:** In this single-center, prospective, observational study, standardized data collection forms were completed by both trainees and supervising emergency physicians (EPs) at the end of each ED shift from August 2009 to March 2010. Shifts with no trainees were excluded. All procedures that were offered to a trainee were recorded as well as the number of potential ED procedures that were, instead, referred to a consulting service. Emergency department crowding was measured in 2 ways: ED length of stay (LOS) and the EP's assessment of crowding during the shift. Poisson regression was used to assess the adjusted effect of ED crowding on the number of trainee procedures performed as well as on the number of procedures given away.

**Results:** There were 804 procedures performed by 113 trainees during 647 trainee shifts. Medical students comprised 51% of trainees. Median number of procedures performed per shift was 1.0 (Fine interquartile range, 0–2.0). Emergency department crowding was not associated with the adjusted number of procedures trainees performed using either the EP's assessment of crowding ( $P = .52$ ) or ED LOS ( $P = .84$ ). Emergency department crowding was associated with an adjusted 256% increase in the mean number of procedures given away ( $P = .02$ ) when measured using physician assessment but was not associated with crowding when assessed using ED LOS ( $P = .06$ ).

**Conclusions:** Crowding was not significantly associated with the number of procedures availed to ED trainees. In patients being considered for admission, however, when the managing EP felt that it was crowded, there was an association with giving procedures to consulting services.

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## 1. Introduction

Residents are the future of the medical profession, and performance of medical procedures is a skill that all physicians must obtain. The Accreditation Council of General Medical Education terms procedural skills a “core competency” [1]. These skills are acquired in medical school and during residency. The emergency department (ED) is a key setting for the acquisition of these skills [2].

Emergency department crowding has been documented in North America as well as much of the Western world [3–5]. Whether ED crowding is affecting the future skills of physicians-in-training is a key issue [6,7], both for educators and for patients. One small study found that crowding had no effect on overall quality of teaching in the ED when measured by trainee ratings; however, this study of 46 trainees did not focus on a specific teaching modality, such as procedural teaching [8]. No study has assessed whether the number of procedures a trainee is offered changes in the setting of ED crowding, although residents and program directors believe that it decreases [9].

In this study, we examined whether the number of procedures offered to a trainee changed during ED crowding as well as whether more procedures were “given away” to consulting services. We hypothesized that the adjusted number of procedures offered to trainees would decrease with ED crowding and that the number given away to consulting services would increase.

## 2. Methods

### 2.1. Study design

This prospective, observational study was conducted from August 14, 2009, to March 14, 2010. Research ethics board approval was obtained from Sunnybrook Health Sciences Centre.

### 2.2. Setting

The ED at Sunnybrook Health Sciences Centre is an academic site that serves 45 000 patients annually. It is a level 1 provincial trauma center and has in-house access to all services except obstetrics (including neurosurgery, vascular surgery, etc). Acuity level is high, with a 24.2% admission rate (relative to 11.4% across in the province), and crowding is commonplace. The site serves as the home of the University of Toronto Emergency Medicine residency program for the city of Toronto, and emergency medicine is a mandatory rotation for first-year residents from all University of Toronto residency programs and final (fourth)–year medical students from the associated medical school, as well as a core site for all emergency medicine residents.

### 2.3. Study population

Medical students doing a rotation in the study ED were eligible if they were in their final 2 years of medical school. Residents in their first 3 years of residency training from any program were also eligible. Resident rotations were 2 months, whereas medical students were present for 1 month. Fourth-year residents and higher were excluded because many of the most common procedures (eg, suturing or casting) would not require supervision, potentially making them less susceptible to the effects of ED crowding.

### 2.4. Data collection

For several years before study commencement, all trainees were mandated to obtain an evaluation card from the supervising emergency physician (EP) for each ED shift. During the study period, 2 standardized, piloted data collection sheets were appended to every evaluation card, with one labeled for the supervising EP and one for either the medical student or resident. Each sheet had an area to list procedures performed, attempted, or offered to the trainee during that shift along with trainee level and type of shift. If the trainee was unable to perform the procedure because of lack of skill (ie, had never performed nor seen the procedure before), the procedure was counted if the supervising physician actively demonstrated the procedure to the trainee. Supervising physicians were also asked how many procedures they gave away to consulting teams: What was the number of procedures the trainee could potentially have done during this shift, but were instead referred to the consulting service, for them to perform (eg, a paracentesis given to team medicine to do instead)?

All shifts were 8 hours in length, and all forms were filled out immediately after the shift. Code names were e-mailed to all participants for signing data collection sheets along with definitions of a procedure; procedures that were standardly performed by a nurse or were part of the physical examination were excluded. Shifts where no eligible trainee was present were excluded. Data were entered into an Excel file by a research assistant, with 20% double data entry.

### 2.5. Method of measurement

Crowding was measured 2 ways. The first was with a dichotomous measure: physician perception of crowding during the shift. Physician perception of crowding has been shown to have good correlation with validated criteria [10]. This was specifically assessed as follows: if the physician answered “yes” to crowding during their shift, he or she was further asked if he or she was (a) very busy managing the ED or (b) there were no beds to see patients in, such that the EP actually had more time available. If the answer was (b), the ED was considered “not crowded”, in terms of teaching availability. If the answer was (a), the ED was considered crowded. This was used to provide a more discerning

assessment of crowding as it relates to teaching compared with standard measures of crowding. However, we also used a standard crowding measure that was continuous: median ED length of stay (LOS) of all patients who were present in the ED during the 8-hour shift that the trainee worked, which was obtained from the Emergency Department Information System software that tracks all ED patients. Emergency department LOS is a commonly used measure in ED crowding research [10] and has been shown to be a good proxy for ED crowding [11]. To internally validate the physician perception measure of crowding with the standard measure used (ED LOS), we also assessed the point biserial correlation between the 2 measures.

## 2.6. Outcome measures

The primary outcome measure was the number of procedures offered to a trainee during a shift. The secondary outcome measure was the number of procedures referred to consulting services.

## 2.7. Data analysis

A sample size calculation was performed using a *t* test. With an estimated mean number of procedures performed of 1.0 (SD, 0.75) per shift during crowded shifts and 1.25 (SD, 0.75) during uncrowded shifts,  $\alpha = .05$  (2-tailed test) and  $\beta = .90$ , 190 shifts per group were required.

Univariate analyses were performed with *t* tests where EP estimate of crowding was used to measure crowding, whereas for median ED LOS, we regressed number of procedures performed on median ED LOS using Poisson regression. Multivariate models were also performed using Poisson regression. These models were estimated using generalized estimating equation methods, which were used to account for clustering by individual EP. In each generalized estimating equation model, the number of procedures performed was regressed on a single measure of ED crowding and a set of additional covariates.

Covariates included trainee level (medical student vs junior resident vs third year resident), type of ED shift and area of the department (day in acute/major area vs day intermediate vs day minor vs evening major vs evening intermediate vs minor intermediate vs night shift), and 2 additional measures of case mix: proportion of patients during that shift with a high-acuity triage score (Canadian Triage and Acuity Scale score of 1/2/3 vs 4/5 [12]) and proportion admitted to hospital. Two regression models were estimated, 1 for each of the 2 measures of ED crowding. Similar Poisson regression models were used to assess the effect of ED crowding on the number of procedures given away to consulting teams. As a sensitivity analysis, all models were also run using negative binomial regression to assess robustness of findings to possible violations of the Poisson assumption. Finally, to assess the effect of multiple trainees

present during a single shift on outcomes, we ran a second sensitivity analysis including this variable but removing trainee level (because trainee level cannot be included in the same model with number of trainees per shift). Adequacy of model fit was assessed using a goodness-of-fit test based on a  $\chi^2$  test of the model deviance. Analyses were performed with SAS software (version 9.2; SAS Institute Inc, Cary, NC).

## 3. Results

During the study period, there were 804 procedures performed by 113 trainees supervised by 38 EPs during 647 shifts. Of the 113 trainees, 58 (51%) were medical students, and 17.8% of shifts had more than 1 trainee present. Median number of procedures performed per trainee shift was 1.0 (interquartile range, 0-2.0), mean, 1.0 (SD, 1.09). From the 44 different procedures performed (online Appendix), the most common were sutures (24.1%), splint/casting (15.3%), fracture reductions (7.3%), arterial blood gases (ABGs) (5.8%), nerve blocks (3.9%), intubations (3.4%), arthrocenteses (3.2%), and lumbar punctures (2.9%).

Internal validation of the 2 crowding measures demonstrated significant correlation ( $P = .009$ ). Of the 589 trainee shifts with an EP assessment of crowding, 206 (35%) were rated as crowded. During crowded shifts, 243 procedures were performed (1.2 procedures per shift; SD, 1.1) vs 423 during the 383 shifts rated as not crowded (1.1 procedures per shift; SD, 1.1) ( $P = .44$ ). Number of procedures performed in crowded vs not crowded shifts is shown by trainee type and shift in Table 1. As the median ED LOS increased, the number of procedures that trainees performed did not change substantially in the univariate analysis ( $-1.8\%$  per each hour increase in median ED LOS,  $P = .51$ ).

**Table 1** Mean number of procedures performed during trainee shifts rated by the EP as crowded vs not crowded, by trainee and shift type

Trainee type	Mean procedures (SD), crowded	Mean procedures (SD), not crowded
Medical student	1.29 (1.18)	1.15 (1.13)
Junior resident	1.13 (1.14)	1.05 (1.11)
Senior resident (third year)	1.06 (1.04)	1.08 (1.07)
Shift type: time of day, area of department (no. of shifts)		
Major day (73)	0.88 (0.60)	0.64 (0.86)
Intermediate day (80)	1.09 (1.34)	1.00 (0.96)
Minor day (71)	2.36 (1.34)	1.77 (1.21)
Major evening (109)	0.69 (0.81)	0.76 (0.94)
Intermediate evening (91)	0.95 (1.08)	0.94 (1.16)
Minor evening (79)	2.17 (1.23)	2.08 (1.12)
Night (95)	0.98 (0.72)	0.85 (0.84)

**Table 2** Poisson regression results: adjusted number of procedures performed, with percent change, by ED crowding (physician perception) and other covariates

Variable	$\beta$ Estimate	% Change ( $e^{\beta}$ )	95% CI	P
EP rates as crowded	.064	6.6	-12.4% to 29.8%	.52
Intermediate day shift <sup>a</sup>	.379	46.1	-2.9% to 119.9%	.07
Minor day shift	.980	166.4	91.2% to 271.0%	<.001
Major evening shift	-.171	-15.8	-46.5% to 32.4%	.46
Intermediate evening shift	.146	15.8	-19.4% to 66.0%	.43
Minor evening shift	.893	144.2	72.1% to 246.6%	<.001
Night shift	-.024	-2.4	-32.7% to 41.5%	.90
Junior resident <sup>b</sup>	-.074	-7.2	-20.1% to 7.9%	.33
Senior resident	.012	1.2	-16.3% to 22.3%	.90
Proportion admitted/shift	1.109	203.1	-4.8% to 865.0%	.06
Proportion high-acuity triage/shift <sup>c</sup>	.268	30.7%	-61.7% to 345.5%	.67

<sup>a</sup> Reference shift: major day.<sup>b</sup> Reference trainee: medical student.<sup>c</sup> Canadian Triage and Acuity Scale score 1/2/3, 5-level scale.

In the regression analyses, when using the EP determination of crowding, there was no significant change in the mean number of procedures performed (6.6% increase in mean number of procedures during ED crowding,  $P = .52$ ) (Table 2). When median ED LOS was used, results were similar (1.0% increase in mean number of procedures per additional hour of median ED LOS,  $P = .84$ ) (Table 3). Instead, working in the minor area of the ED predicted a higher number of procedures offered to trainees (using either measure of crowding) compared with the major area. Both sensitivity analyses (negative binomial regression and inclusion of number of trainees working per shift instead of trainee level) had similar results.

During 567 trainee shifts where the EP answered whether they referred any procedures to consultants, 34 were given away (5.1% of 670 potential procedures during those shifts). During shifts rated as not crowded, 3.4% (95% confidence interval [CI], 1.8%-5.9%) was given away vs 10.5% (95%

CI, 6.4%-15.9%) during crowded shifts ( $P = .02$ ). For every hour increase in median ED LOS, there was no significant change (5.0% decrease in mean number of procedures referred per shift,  $P = .71$ ). In the multivariate regression model, when using EP assessment of crowding, the adjusted mean number of procedures given away during crowded shifts increased by 256% ( $P = .02$ ) (Table 4), whereas the difference was not statistically significant for every hour increase in median ED LOS (-21.3%,  $P = .06$ ). Results of the sensitivity analyses were similar.

#### 4. Discussion

This is the first study to report the effect of ED crowding on the number of procedures that the trainees are offered during their training in the ED. Among more than 800 procedures performed, we found no relationship between the

**Table 3** Poisson regression results: adjusted number of procedures performed, with percent change, by ED crowding using median ED LOS and other covariates

Variable	$\beta$ Estimate	% Change ( $e^{\beta}$ )	95% CI	P
Median ED LOS	.007	1.0	-6.2% to 8.1%	.84
Intermediate day shift <sup>a</sup>	.378	45.9	1.9% to 108.8%	.04
Minor day shift	1.120	206.5	129.8% to 309.2%	<.001
Major evening shift	-.058	-5.7	-40.1% to 48.4%	.80
Intermediate evening shift	.218	24.4	-12.8% to 77.3%	.23
Minor evening shift	.999	171.6	97.6% to 272.8%	<.001
Night shift	.043	4.4	-26.3% to 47.7%	.81
Junior resident <sup>b</sup>	-.095	-9.1	-23.1% to 7.6%	.27
Senior resident	-.029	-2.9	-19.4% to 17.1%	.76
Proportion admitted/shift	.979	166.2%	-19.4% to 779.3%	.11
Proportion high-acuity triage/shift <sup>c</sup>	.263	30.1	-55.5% to 280.3%	.63

<sup>a</sup> Reference shift: major day.<sup>b</sup> Reference trainee: medical student.<sup>c</sup> Canadian Triage and Acuity Scale score 1/2/3, 5-level scale.



**Table 4** Poisson regression results: adjusted number of procedures given to consulting teams, with percent change, by ED crowding (physician perception) and other covariates

Variable	$\beta$ Estimate	% Change ( $e^{\beta}$ )	95% CI	P
EP rates as crowded	1.274	257.5	26.8% to 909.0%	.02
Intermediate day shift <sup>a</sup>	.501	65.0	−39.3% to 352.5%	.32
Minor day shift	−1.461	−77.8	−96.4% to 49.2%	.12
Major evening shift	−1.005	−63.4	−91.6% to 64.0%	.18
Intermediate evening shift	−.499	−39.3%	−84.2% to 133.3%	.47
Minor evening shift	−1.610	−80.0%	−97.8% to 77.9%	.15
Night shift	.245	27.8%	−77.5% to 625.6%	.78
Junior resident <sup>b</sup>	0.103	10.8	−51.2% to 152.0%	.81
Senior resident	.518	67.9	−87.1% to 175.1%	.51
Proportion admitted/shift	−.693	−50.0%	−99.9% to 609.2%	.78
Proportion high-acuity triage/shift <sup>c</sup>	1.967	614.9	−44.3% to 677.2%	.10

<sup>a</sup> Reference shift: major day.<sup>b</sup> Reference trainee: medical student.<sup>c</sup> Canadian Triage and Acuity Scale score 1/2/3, 5-level scale.

number of procedures performed in the ED relative to the ED crowding status regardless of how crowding was defined. This is reassuring to both educators and trainees as well as to patients who will be receiving procedures from physicians who trained during an era of ED crowding.

The effect of crowding on trainee procedures is complex; others have noted the multifactorial nature of crowding that can be both additive and detrimental to education [2]. Some hypothesize that crowding, when it leads to bed block, may lead to more opportunities for ED trainees to perform procedures [2], which could also potentially explain our findings.

We did find, however, an adjusted 2 ½ times increase in the number of ED procedures given away to consulting services during periods of ED crowding as measured by the EP's opinion. This was not found when measuring crowding using the conventional ED LOS. The difference may stem from how we measured crowding; EP opinion has been shown to correlate well with other crowding measures [10], but in our EP assessment, we captured when the ED was very crowded, but bed block gave the EP more free time (potentially for teaching). In our EP assessment measure, these shifts were classified as not crowded, but using median ED LOS, they would have been classified as crowded, thus potentially leading to the divergent results.

It is perhaps not surprising that, during ED crowding, EPs give away some procedures on patients awaiting admission when they are busy managing the department, and there are others around to perform potentially time-consuming procedures. However, given that less than a quarter of patients are admitted, and that procedures on admitted patients are less frequent than those on discharged ED patients, the referred procedures' rate likely makes a relatively small impact on the overall number of procedures a trainee is offered in a crowded ED. In addition, our number of referred procedures was small at 34; future studies are needed to confirm this preliminary finding.

Emergency department crowding has been shown to negatively impact a multitude of quality-of-care measures, including time to antibiotics [13], time to pain medication [14], and mortality [15]. To our knowledge, no previous studies on the number of procedures performed in the ED are available for comparison. Overall quality of ED teaching during ED crowding has been assessed by a study of 46 trainees [8] that found no differences in Likert ratings, similar to our findings for our primary outcome.

This study has several limitations. It was performed at a single site that is the home base for the emergency medicine residency training program, limiting the generalizability to teaching sites. The results may only apply to sites with similar levels of crowding such as that of the study site. Increased volumes in the afternoons and evenings lead to long waiting times during those periods; during the study period, the median value of our crowding measure "median ED LOS" was 5.0 hours between 16:00 and 01:00, whereas the mean of the mean ED LOS was 8.0 hours, with a range of 4.4 to 13.7 hours. Given that these are averages of averages, very long ED LOSs occurred at the study ED. Because of financial constraints, the study was not performed over an entire year; however, it ran from mid-August to mid-March, which includes all 4 seasons and may remove some of the "July effect" or effect of very new trainees (who may need more procedural supervision), which could have biased our results. Although we provided guidelines to define a "procedure," we did not provide a specific list given that the length of the list might discourage study participation. This likely leads to lower representation of procedures that are not clearly considered procedures (eg, fecal occult blood testing); however, these minor procedures are less concerning to teachers and learners than more obvious procedures, such as intubations or suturing. We did not assess potential procedures given away to an outpatient setting (eg, trial of antibiotics for small abscess, conservative hemorrhoid treatment, etc), which could affect the "total" number of potential procedures; we did not assess these "possible"

procedures because different physicians would likely categorize these differently (ie, interrater reliability would be poor) nor did we assess whether crowding affects some types of procedures more than others; this would make an excellent future study.

## 5. Conclusions

Contrary to our study hypothesis, ED crowding was not associated with decreased opportunity for trainees to perform procedures. Crowding appeared to be associated with an increase in number of procedures referred to consulting services when the EP was busy managing the ED, but it does not appear to affect overall procedures available to the ED trainee.

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## References

- [1] Accreditation Council for Graduate Medical Education (Acgme). Program Directors and Coordinators. [http://www.acgme.org/acWebsite/navPages/nav\\_PDcoord.asp](http://www.acgme.org/acWebsite/navPages/nav_PDcoord.asp). 2011.
- [2] Shayne P, Lin M, Ufberg JW, et al. The effect of emergency department crowding on education: blessing or curse? *Acad Emerg Med* 2009;16:76-82.
- [3] Institute of Medicine. Hospital-based emergency care: at the breaking point. Washington (DC): National Academy Press; 2006.
- [4] Proudlove NC, Gordon K, Boaden R. Can good bed management solve the overcrowding in accident and emergency departments? *Emerg Med J* 2003;20:149-55.
- [5] Schull MJ, Szalai JP, Schwartz B, et al. Emergency department overcrowding following systematic hospital restructuring: trends at twenty hospitals over ten years. *Acad Emerg Med* 2001;8:1037-43.
- [6] Atzema C, Bandiera G, Schull MJ. Emergency department crowding: the effect on resident education. *Ann Emerg Med* 2005;45:276-81.
- [7] Fisher J, Sokolove PE, Kelly SP. Overcrowding: harming the patients of tomorrow? *Acad Emerg Med* 2009;16:56-60.
- [8] Pines JM, Prabhu A, McCusker CM, et al. The effect of ED crowding on education. *Am J Emerg Med* 2010;28:217-20.
- [9] Petrosniak A, Woolfrey K. Achieving competence in procedural skills: a survey of Canadian emergency medicine residents and program directors. *CJEM* 2011;13(2):195-6.
- [10] Hwang U, McCarthy ML, Aronsky D, et al. Measures of crowding in the emergency department: a systematic review. *Acad Emerg Med* 2011;18:527-38.
- [11] McCarthy ML, Zeger SL, Ding R, et al. Crowding delays treatment and lengthens emergency department length of stay, even among high-acuity patients. *Ann Emerg Med* 2009;54:492-503.
- [12] Beveridge R, Clarke B, Janes L, et al. Implementation guidelines for The Canadian Emergency Department Triage & Acuity Scale (CTAS). <http://www.caep.ca/template.asp?id=98758372CC0F45FB826FFF49812638DD1998>.
- [13] Pines JM, Localio AR, Hollander JE, et al. The impact of emergency department crowding measures on time to antibiotics for patients with community-acquired pneumonia. *Ann Emerg Med* 2007;50:510-6.
- [14] Pines JM, Hollander JE. Emergency department crowding is associated with poor care for patients with severe pain. *Ann Emerg Med* 2008;51:1-5.
- [15] Chalfin DB, Trzeciak S, Likourezos A, et al. Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit. *Crit Care Med* 2007;35:1477-83.